REMARKS/ARGUMENTS

Reconsideration is respectfully requested.

Claims 1-13 are pending before this amendment. By the present amendment, claims 1, 10, and 13 are amended. No new matter has been added.

Claims 1-4, 6, 10 and 13 stand rejected under 35 U.S.C. §103(a) as being obvious over U.S. Patent No. 5,485,613 (Engelstad) in view of U.S. Patent No. 5,640,529 (Hasbun). The "et al." suffix is omitted in a reference name.

The applicants respectfully **disagree**.

The presently claimed invention is directed to a garbage collection method that balances the load of garbage collection by distributing and performing the garbage collection in a plurality of communication cycles. Utilizing a list of items to be deleted, the deletion of the items in the list can be distributed during the command and response of a communication cycle according to a calculated time such that a user does not feel the affects of the garbage collection process. By distributing the garbage collection process over multiple cycles using a list of items to be deleted rather than requiring writing as in conventional mark and sweep garbage collection processes, the present invention allows for a quicker and more efficient garbage collection process that is not felt by the end user.

The present invention allows for a garbage collection process to occur between a command response from a host or terminal such that the garbage collection does not exceed a user endurable time limit 160, e.g., Quality of Service, or a response time limit 162, i.e., a preset time for response from the smart card (specification page 5, lines 22-28; FIG. 1D). Conventional mark and sweep garbage collection requires time to list

objects, i.e., mark objects, to be deleted from memory. This may result in a delayed response time that is directly felt by the user. Unlike the traditional mark and sweep garbage collection that requires actual information to be stored in the memory for objects to be deleted, e.g., an additional bit or flag stored with each object, the present invention requires only memory for the performance of the garbage collection (specification page 6, 23-33). That is to say, by utilizing a list of objects to be deleted, the present invention does **not require** the marking of each object to be deleted. This is very important in that the time required to mark each and every object to be deleted is then moot. In addition, this lowers the amount of writes to the writeable non-volatile memory, i.e., the EEPROM, which is beneficial to the longevity of the memory medium since such memory has a maximum number of writes for its lifetime.

More specifically, the present invention reduces the possibility of a response delay by calculating an available time for garbage collection and distributing the garbage collection across a plurality of communication cycles (specification page 7, lines 21-25). According to the present invention, a list of objects that should be deleted is formed (specification page 7, lines 27-29). The list is generated when either garbage collection is requested or a communication session of a smart card is initialized. During a sweep phase of the garbage collection process according to an embodiment of the present invention, a residual time up to the response time limit of the smart card is measured "on the basis of the list of objects to be deleted" (specification page 8, lines 7-14). Then during the calculated residual time, the items in the list of items to be deleted are deleted. That is, utilizing the list of items to be deleted, the garbage collection method of the present invention determines how much garbage collection can be

performed during a communication cycle so that the overall time of the communication cycle including the command, garbage collection, and response is within a response time limit, or more preferably, within a user's set time limit.

Referring to FIG. 3B of the present invention, a residual time is calculated 312 such that the garbage collection is performed 314 within an acceptable time for a communication cycle. If the garbage collection can be finished in the residual time, the smart card finishes the garbage collection (specification page 8, lines 24-25). Generally referring to FIGS. 3C through 3G, the present invention allows the garbage collection to be spread across multiple communication cycles if a garbage collection process cannot be completed in the calculated residual time. As shown in FIG. 3C, garbage collection 1-1 is performed 320, but does not finish in the calculated residual time. As a result, the garbage collection resumes in a subsequent communication cycle as garbage collection 1-2 322. Therefore, since the garbage collection is distributed over multiple communication cycles, the response time of the smart card does not exceed a set response time limit and does not present the danger of increasing the delay of the response time as in the conventional mark and sweep methods.

That is to say, the present invention separately performs a mark phase and a sweep phase. If the objects to be deleted remain after performing the mark phase and the sweep phase during one communication cycle, then **only** the sweep phase is performed during the next plurality of communication cycles.

To further clarify these aspects of the present invention, claim 1 (and similarly claims 10 and 13) has been amended as follows, inter alia:

> -- **performing a mark phase during a communication cycle, the mark phase for** making a first list of objects to be deleted from the writeable non-

volatile memory;

performing a sweep phase during the communication cycle until deleting all the listed objects of the first list from the memory, wherein the performing of the sweep phase comprises--

and

--**and wherein, if objects to be deleted remain after performing the mark phase and the sweep phase during the communication cycle, only the sweep phase is performed during the other communication cycles**--

The support for these amendments can be found in the specification in at least page 7, line 21 - page 8, line 14 and FIGS. 3A-3G.

In the Office Action (page 2), the examiner states that Hasbun teaches a garbage collection method performed during a plurality of communication cycles and the calculation of a residual time.

Hasbun is directed to a method of clean-up that is performed based on an examination of available free memory (Hasbun col. 3, lines 49-52). Accordingly, Hasbun provides a method of clean-up for preventing the overrun of a clean-up process that would adversely affect the perceived performance of a solid state disk (Hasbun col. 3, lines 52-56).

Firstly, Hasbun cannot teach the presently clamed invention since Hasbun does not teach the separation of the mark and sweep phase as in the presently claimed invention. That is, Hasbun cannot teach --**and wherein, if objects to be deleted remain after performing the mark phase and the sweep phase during the communication cycle, only the sweep phase is performed during the other communication cycles**-- as in amended claim 1. Hasbun teaching the mark and sweep phases as being performed together. That is, Hasbun teaches that when a host command is received from the host CPU 52, the host command is executed and then

available free memory is examined to determine whether clean-up is necessary (Hasbun col. 3, lines 49-56). More simply, Hasbun discloses performing both a mark and sweep phase together upon receipt of a host command. Therefore, in no way can Hasbun teach separately performing the mark and the sweep phase in the presently claimed invention.

The examiner asserts that Hasbun teaches the "calculating [of] a residual time" (Office Action page 3). However, the timer referenced in Hasbun is not the same as the --residual time-- of the presently claimed invention. In Hasbun, once a command interrupt is received from a CPU 52, microprocessor 92 sets a watch dog timer 165 **to the maximum time allowed for execution of the command** (Hasbun col. 10, line 66 to col. 11, line 4). This is illustrated as step 402 in FIG. 8 of Hasbun. That is, the watch dog timer 165 is set to the maximum time remaining after execution of a the received command. This is very different from the present invention. In the present invention, the --residual time-- is calculated according to the first list of objects to be deleted up to a predetermined time limit after processing an external command. That is to say, the residual time is **not** the maximum time remaining after the execution of an external command as taught in Hasbun.

Further, Hasbun explicitly states that the perceived performance of the solid state disk 60 is tied to the amount of time required for clean up (Hasbun col. 11, lines 10-61). Hasbun describes a method where the clean up is dependent on the amount of free memory available. That is, Hasbun states that a certain amount of free memory, or lack thereof, acts a trigger for the clean up process (Hasbun col. 11, lines 10-14). As described in Hasbun, the perceived performance of the solid state disk 60 will fall as the

trigger amount increases (Hasbun col. 11, lines 19-22). Conversely, the greater the trigger amount, the greater the perceived delay. According to Hasbun, the clean up process disclosed is related to the amount of free memory currently available within FLASH array 62 (Hasbun col. 11, lines 62-65). Taking this in light of the previous description given by Hasbun, the clean up process of Hasbun may increase a perceived delay depending on the triggering amount. This scenario is exactly that which the present invention seeks to avoid. By distributing a garbage collection process over multiple communication cycles, the occurrence of an increase in perceived delay by a user is removed since the garbage collection is only performed in the residual time up the a predetermined time limit, i.e., an acceptable response time. That is, Hasbun teaches a combined mark and sweep phase in contradistinction to the presently claimed invention.

Therefore, the clean up process of Hasbun does not guarantee a response time, but rather is dependent on a predetermined amount of memory to act as the trigger. Accordingly, Hasbun does not calculate a --residual time-- as in the presently claimed invention.

In the Office Action (page 2), the examiner states that Engelstad teaches all the remaining limitations of claim 1 of the present invention. Firstly, the applicants would like to note that although Engelstad is directed to a form of garbage collection, the garbage collection disclosed is different from that of the present invention. Garbage collection is a process by which to reclaim certain objects in memory. However, the term garbage collection is applied to multiple different scenarios. For example, in the present invention, garbage collection is performed to reclaim memory in an EEPROM, e.g., Flash memory,

whereas in Engelstad garbage collection is performed in an object oriented system to reclaim memory according to created objects. Although both systems reclaim memory, the underlying process is different since they concentrate on very specific types of garbage collection. That is, the present invention is directed to memory reclamation and Engelstad is directed to programming or software garbage collection.

The garbage collection of Engelstad focuses on a condemned region and **not all objects** of a memory space (Engelstad col. 3, lines 14-17). This in and of it self is different from the present invention in that the present invention creates a list of items to be deleted irrespective of where it is in the memory. The present invention considers the entire memory for the purpose of garbage collection. This distinct difference between the present invention and Engelstad is one example as to how garbage collection can be directed to specific functions. In a programming environment, certain objects may be referenced continually while other objects are created and discarded after use. It is assumed that the certain objects that are continually referenced are created first and subsequent objects would be those that would be discarded after use. As such, rather than scanning or listing objects to be deleted from an entire memory block, it would be more efficient to determine an area of memory that contains only newer objects as those would be most likely to be discarded in order to regain memory. This is exactly what is described in Engelstad. By determining a condemned region, Engelstad is isolating only a portion of memory assuming that anything not in the condemned region does not have anything to be reclaimed.

The applicants respectfully resubmit their previously filed arguments with respect to the examiner's assertion that the condemned region described in Engelstad teaches

a --list of objects-- as claimed in the present invention. In addition, the applicants submit that the new amendments to the claims further clarify these aspects.

The examiner's assertion that Engelstad's condemned region is equivalent to the claimed list --list of objects-- is not accurate. The --list of objects-- in amended claim 1 of the present invention allows for the calculation of a --residual time-- so as to distribute the deletion of objects during garbage collection across multiple communication cycles. By using the list of objects to be deleted, the memory does **not** need to be scanned in order to determine how many objects should be deleted as in the conventional mark and sweep method. That is, in a conventional marking method where the individual objects are each individually marked, a scan of the memory area would be required in order to determine the number of objects to be deleted. This adds an additional step to a garbage collection process and further increases the total time needed for a garbage collection process. In contradistinction, the presently claimed invention relies on a list that does not include the marking of individual objects to be deleted and therefore simple reference to the list avoids the necessity of a scan and any additional time that would be associated with such a scan.

In Engelstad, the tasks associated with Phase 8, i.e., garbage reclamation, includes a generation scan (Engelstad col. 27, lines 17-22). Engelstad describes the process as including the garbage collector "sequentially check[ing] each object in the generation to determine if the object is marked" (Engelstad col. 27, lines 11-13). The additional step of scanning the memory requires additional time thereby prolonging the garbage collection process. Further, even if the condemned region of Engelstad were to be considered a "list" as in the present invention, the calculation of a --residual time-- as

in the present invention would be pointless. That is, Engelstad would scan the memory to determine the objects to be deleted, in oder to determine the time it would take to scan the memory for objects to be deleted. This process would be completely redundant. Therefore, alleging that the condemned region of Engelstad is equivalent to the claimed --list of objects-- is not accurate in that the condemned region of Engelstad **cannot** provide the same benefits as the --list of objects-- claimed in claim 1of the present invention. These benefits are clearly claimed in amended claim 1 as the --residual time-- is calculated according to the --list of objects--.

Engelstad also performs garbage collection according to the allocation of resources rather than when called on. Meaning, the garbage collector of Engelstad runs as part of an allocation process every N occurrences of allocation of memory for new objects (Engelstad col. 11, lines 44-47). The variable N is called the "cycle steal interval" and cab be adjusted (Engelstad col. 11, lines 47-52). As a result, garbage collection does not continually run in Engelstad, but is tied directly to the allocation of resources. This is fundamentally different from the present invention in that once an item is to be deleted it is immediately added to the deletion list (or generates a new list if one is not currently generated) and is scheduled to be deleted in the next available residual time. Unlike the present invention, Engelstad only performs garbage collection according to a set schedule. That is both the mark and sweep phase of Engelstad is performed together, not separately as in the presently claimed invention.

Engelstad describes the garbage collection process as a duty cycle comprising a set of eight internal phases (Engelstad col. 11, lines 58-60). The duty cycle selects a set of generations to search for unreachable objects, i.e., objects to be deleted. A duty

cycle is comprised of phases. A phase comprises one or more cycles, each being an individual real-time segment in which the garbage collector performs work (Engelstad col. 12, lines 1-3). A cycle comprises one or more discrete tasks. A task is an **indivisible portion** of the garbage collector's work and **"must complete within one cycle"** (Engelstad col. 12, lines 4-6). That is, a single task must complete in one real-time segment and cannot be distributed across multiple cycles according to Engelstad.

The examiner asserts in page 4 of the Office Action that "after each task the garbage collector may be exited and completed later" and references FIG. 4 of Engelstad. The examiner cites this as teaching the limitation of -- such that the objects in the updated first list are available for deletion in another communication cycle-- as in amended claim 1. However, according to Engelstad this is not so. Engelstad explicitly states that a task "must complete within one cycle" and is indivisible (Engelstad col. 12, lines 4-6). Engelstad describes the garbage reclamation phase (phase 8) of the garbage collector in col. 27. More specifically, Engelstad teaches that "Free[ing] an object" is a single task (Engelstad col. 27, lines 17-22). Therefore, according to Engelstad's description of a task and its characteristics, the freeing of an object, or the deletion of objects, **cannot** be performed over multiple communication cycles as in the present invention. Further, Engelstad teaches that the cycle steal interval can be adjusted which may affect response time (Engelstad col. 27, lines 24-36).

Therefore, Engelstad cannot teach the presently claimed invention in that the "task" of freeing an object can be performed across multiple communication cycles since it must complete in a single cycle. Further, the condemned region described in Engelstad is not the same as the --list of objects to be deleted-- as in claim 1 of the

present invention. As a result, Engelstad cannot teach the presently claimed invention.

That is, like Hasbun, Engelstad does not teach separately performing a mark and sweep phase as in the presently claimed invention. The presently claimed invention is structured such that a separate sweep phase can be performed --**if objects to be deleted remain after performing the mark phase and the sweep phase during the communication cycle**-- as in amended claim 1. If the objects remain --**only the sweep phase is performed during the other communication cycles**--. This is completely different from Engelstad that requires the mark and sweep phase to be performed together.

Accordingly, neither Hasbun nor Engelstad, whether considered individually or combination, teach or suggest all of the claimed limitations of amended claim 1. Therefore, the applicants respectfully solicit an indication of allowable subject matter with respect to claim 1 for at least the reasons set forth above.

As to independent claims 10 and 13, the applicants respectfully resubmit their arguments with respect to claim 1. Since neither Engelstad nor Hasbun teach or suggest all the limitations of claims 10 and 13 for the at least the reasons set forth above, the applicants respectfully request withdrawal of the rejection and earnestly solicit and indication of allowable subject matter.

As to claims 2-9 and 11-12, the applicants respectfully submit that these claims are allowable at least since they depend from independent claims 1 and 10, which are now considered to be in condition for allowance for at least the reasons set forth above. Accordingly, the applicants respectfully request withdrawal of the outstanding rejections

and earnestly solicit an indication of allowable subject matter.

For the reasons set forth above, the applicants respectfully submit that claims 1-13, pending in this application, are in condition for allowance over the cited references. Accordingly, the applicants respectfully request reconsideration and withdrawal of the outstanding rejections and earnestly solicit an indication of allowable subject matter.

This amendment is considered to be responsive to all points raised in the office action. Should the examiner have any remaining questions or concerns, the examiner is encouraged to contact the undersigned attorney by telephone to expeditiously resolve such concerns.

Respectfully submitted,

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